(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

BE

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
11 January 2001 (11.01.2001)

PCT

(10) International Publication Number
WO 01/02146 A1

(51) International Patent Classification[7]: B29C 33/40, 70/48, 33/00

(21) International Application Number: PCT/GB00/02376

(22) International Filing Date: 30 June 2000 (30.06.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
9915505.3 3 July 1999 (03.07.1999) GB

(71) Applicant and
(72) Inventor: HARPER, Alan, Roger [GB/GB]; Plastech Thermoset Tectonics, Unit 1, Delaware Road, Gunnislake, Cornwall PL18 9AR (GB).

(74) Agent: BROWN, Michael, Stanley; Alpha & Omega, Chine Croft, East Hill, Ottery St. Mary, Devon EX11 1PJ (GB).

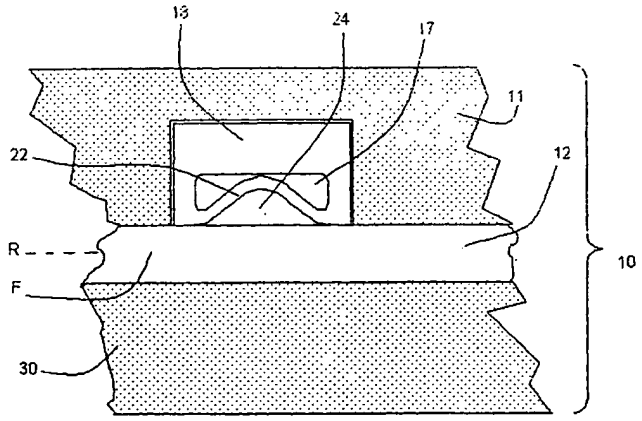
(81) Designated States *(national)*: IL, JP, MX, NO, SG, US, ZA.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published:
— *With international search report.*
— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: RESIN TRANSFER TOOL AND METHOD USING AN ELASTOMERIC INSERT TO DEFINE A RUNNER CHANNEL



(57) Abstract: A mould tool (10) for resin transfer moulding having a first member (11) defining a face mould surface (12) and a second member defining a contra mould surface wherein there is provided in at least one of members (11) for the mould surface (12) defined by the member; a channel (13) and an elastomeric member (18) located in and by the channel (13) defining in part a flexible wall (22) for the region; a pressurisible duct (17) extending through the elastomeric member (18); a passage (23) extending from the interior of the duct (17) to a location outside the mould member (11) whereby the pressure within the duct (17) can be varied to cause displacement of the flexible wall (22) between a first position (Figure 2) wherein the wall (22) is drawn inwardly to define and maintain a runner channel (24) in the mould surface of the member; and a second position wherein the wall (2) is released from forming the runner channel (24) and serves to provide a wall for the mould surface (12) of the member conforming substantially to that of the mould surface adjacent the channel (13).

WO 01/02146 A1

RESIN TRANSFER TOOL AND METHOD USING AN ELASTOMERIC INSERT TO DEFINE A RUNNER CHANNEL

TECHNICAL FIELD

This invention relates to improved liquid polymer flow. It is particularly, but not exclusively, concerned with improved liquid polymer flow in the field of resin transfer moulding ('RTM'). It can also be used for systems such as composite vacuum fusion moulding.

BACKGROUND ART

RTM is a method of moulding composite parts of polymer and fibre which is now being adopted widely by moulders throughout the world as a cleaner and more efficient manufacturing method over traditional open moulding techniques such as hand lay-up or spray deposition. The RTM method is now a preferred route for the manufacture of composite moulded parts both large and small. It is applicable to a wide spectrum of products ranging from general industrial mouldings to advanced composite aerospace mouldings.

Significant development has taken place to optimise the RTM process in reducing production cycle times. One major area of optimisation involves the actual speed of mixed resin flow into the fibre pack which is held within a closed RTM mould. The main method of increasing resin flow is to increase the injection pressure. However this has major disadvantages which include the following.

a) The RTM process is regarded as a low pressure process (that is to say below 7 bar). Conventionally RTM mould tools are made from cost effective reinforced composite materials rather than block metal, aluminium/steel. Increasing polymer input pressures beyond the normally accepted low maximum level causes composite moulds to deflect with the consequent production of inaccurately moulded parts.

b) Higher injection pressures result in faster polymer injection speeds and higher velocity at the injection point. This can give rise to fibre pack movement or

'washing' at or around the injection point and increase the likelihood of product rejection.

The purpose of this invention is to enable the combination of higher injection flow, rates without the disadvantages outlined above and provides an improvement on traditional methods currently employed.

Traditionally the accepted method of providing for increased flow of liquid polymer into a closed mould within which the dry fibre pack awaits infusion is to provide a 'resin runner' in one half of the mould faces. This is a recess in the surface of the mould having a cross section into which compacted dry fibre will not readily fit so ensuring that the channel remains open throughout the injection process to provide a clear path for flowing injected polymer. By positioning the mould injection point to communicate with this open channel the injected resin, upon first entering the mould sees an open, high permeability, flow path in which to flow and from which to permeate into and around the fibre pack. In mould design such a resin flow channel is sometimes termed a 'mould sprue runner'.

A flow channel design has geometric limitations within the overall mould tool geometry so that a flowing resin front must eventually be forced to pass through a lower permeable fibre pack without finding a shortcut to the mould cavity final fill points. This can result in some of the fibre pack being left dry or only partially impregnated.

A conventional high flow permeable flow channel shape incorporated in a mould surface will result in a moulded part, on removal after cure from the mould, having a resin rich moulded line upon its surface. For many products this is unacceptable.

The present invention serves to provide a low permeable channel within the mould surface while avoiding the generation of resin rich moulded line.

DISCLOSURE OF INVENTION

According to a first aspect of the present invention there is provided a mould tool for resin transfer moulding having a first member defining a face mould surface and a second member defining a contra mould surface whereby, when in a juxtaposed working relationship, the first and second members form a mould region; wherein there is provided in at least one of members for the mould surface defined by the member;

a channel with a first cross section including a region opening into the interior of the mould region; and

an elastomeric member located in and by the channel defining in part a flexible wall for the region;

a pressurisible duct extending through the elastomeric member;

a passage extending from the interior of the duct to a location outside the mould member whereby the pressure within the duct can be varied to cause displacement of the flexible wall between a first position wherein the wall is drawn inwardly to define and maintain a runner channel in the mould surface of the member; and a second position wherein the wall is released from forming the channel and serves to provide a wall for the mould surface of the member conforming substantially to that of the mould surface adjacent the channel.

According to a first preferred version of the first aspect of the present invention the channel has opening into it in a location not occupied by the elastomeric member forming an injection port whereby liquid resin can be injected into the mould.

According to a second aspect of the present invention there is provided a method of resin transfer moulding utilising a mould comprising a first member defining a face mould surface and a second member defining a contra mould surface whereby, when in a juxtaposed working relationship, the members serve to bound a mould region comprising the steps of:

providing in the first member defining the face mould surface or the second member defining the contra mould surface or in each a channel incorporating an elastomeric member (which is hollow so as to provide an internal duct) the elastomeric member extending over a path in the or each surface with a face of the elastomeric member directed towards the mould region;
providing for the face of the elastomeric member to be moved relative to the channel between:
a first state where the face is in a first configuration conforming to the surrounding region of the mould surface adjacent the channel; and
a second state where the face is in a second configuration retracted from the first into the channel so as to increase the volume of the mould region and thereby providing a channel through which mobile material (such as liquid resin) in the vicinity of the elastomeric member can flow.

According to a first preferred version of the second aspect of the present invention the step of providing for the face to move from the first state to the second state is caused by applying a vacuum to the internal duct.

According to a second preferred version of the second aspect of the present invention or of the first preferred version thereof the step of providing for the face to move from the second state to the first state is caused by applying an overpressure to the internal duct.

According to a third aspect of the present invention there is provided a moulded article produced by means of a mould tool according to the first aspect or any preferred version thereof.

According to a fourth aspect of the present invention there is provided a moulded article produced by means of a method according to the second aspect or any preferred version thereof.

BRIEF DESCRIPTION OF DRAWINGS

An exemplary embodiment of the invention will now be described with reference to the accompanying drawings of a part of a moulding machine used for resin transfer moulding of which;

Figure 1 shows a sectional elevation of a first member defining a mould surface;

Figure 2 shows a sectional elevation of another part of the first member; and

Figure 3 shows the assembly of Figure 3 in use in combination with a second member defining a mould surface.

MODE FOR CARRYING OUT THE INVENTION

FIGURES 1 AND 2

Mould 10 includes a contra mould member 11 in surface 12 of which is located a channel 13 which is of rectangular section recess with flat walls 14, 15, 16 and an open periphery P. The channel 13 extends for a major part of the length of the contra mould member 11. The channel 13 helps to facilitate the ready distribution of liquid polymer during its injection into the mould 10 as will be described hereafter with reference to Figure 3.

An elastomeric member 18 is located in and by the channel 13. The elastomeric member 18 has side walls 19, 20, 21 which seat on and are located by, respectively, walls 14, 15, 16 of the channel 13. Side wall 22 of the member 18 serves as a flexible wall closing open periphery 17of the channel 13.

The member 18 incorporates a duct 17 extending the length of the member but with either end of the duct 17 closed so that the duct 17 can serve as a chamber whose volume can be varied by varying the pressure of gas or fluid within the duct 17. To this end there is provided (Figure 1) a passage 23 through member 11 to the interior of the duct 17 from a location outside the mould member 11 where means are provided to pressurise the duct 17 to cause displacement of the flexible wall 22 between a first position (as shown in Figure 2) wherein the wall 22 is drawn inwardly to define and

maintain a runner channel 24 in the mould surface of the member 11; and a second position (as shown in Figure 1) wherein the wall 22 is caused to revert to a form a wall conforming substantially to that of the mould surface 12 in the vicinity of channel 13.

The elastomeric member 18 can be manufactured in unlimited lengths. A closed mould matching set is readily designed and fabricated to accept the member in the mould face and the path of the or each channel can be selected to provide for an optimised path for polymer flow into the mould.

The member 18 is glued to the three walls 14, 15, 16 of the channel 13 so as to secure the member 18 firmly into position with the exposed face 22 flush with the surrounding mould surface 12. A suitable mould resin injection port is designed and positioned either at one end of channel 13 or some way along its length with separate elastomeric members corresponding to member 18 in the channel on either side of the injection port.

FIGURE 3

In operation the mould 10 is closed and contra mould 11 is clamped shut with face mould 30 to form a mould region R. clamped together over a fibre pack F.

A vacuum is connected to the duct 17 as described in connection with Figure 1 in order to deform the member 18 to provide a flow channe0l 24 over the fibre pack F. An injection matrix is made to enter the mould 10 by way of one or more injection ports similar to that described in connection with Figures 1 and 2. The provision of the channel 24, and any available similar channels enables the incoming liquid resin to flow more readily above the fibre pack. Matrix injection continues in this way until the mould region R is full with the fibre pack F fully wetted and impregnated.

Once filling of mould region R is complete the vacuum maintaining the channel 24 is removed and replaced with gas at atmospheric or above atmospheric pressure. As a

result the member 18 reverts to the form shown in Figure 2 where channel 24 has disappeared and wall 22 conforms in level to the adjacent form of the surface 12 as shown in Figure 1.As a result no residual channel space similar to channel 24 is left for polymer rich material to occupy and harden in.

In the case of the exemplary embodiment the channel 13 for receiving the elastomeric member 18 is of rectangular cross section. However any convenient cross section can be used together with an elastomeric member of complementary cross section.

The face of the wall 22 of the elastomeric member 18 can be fabricated to give a slight outward bow so that its natural position when not subject to positive, or negative, pressure whilst positioned against the fibre pack F after injection is slightly positive. This is to prevent negative buckling or deformation under the residual pressure of either the liquid matrix or the fibre pack F.

The use and application of an actual vacuum in duct 17 may not be required as the matrix injection pressure may be sufficient to deflect the member 18 to establish a sufficient size of channel providing easy priority flow of liquid matrix along the created flow channel.

The invention in its second aspect provides a method of manufacturing a moulded article by providing in one or more of mould face surfaces in a mould a channel for a resilient member. A part of the resilient member can be displaced from a position flush with the surrounding surface of the mould face to a position retracted from the surrounding surface to provide a flow channel enabling liquid resin to readily flow across the face of, for example, a preformed fibre pack located in the mould. Following completion of resin injection, but prior to polymerisation, the resilient member is caused to revert to its flush state so as to ensure the resulting moulding arises from a mould from which the flow channel has effectively been removed.

INDUSTRIAL APPLICABILITY

The invention provides for improved apparatus and method for resin transfer moulding which is an established process for manufacturing mould parts. Typically it provides for more rapid and more reproducible moulding steps with reduced faulty mouldings arising from overpressure and 'washing'.

CLAIMS

1 A mould tool for resin transfer moulding having a first member defining a face mould surface and a second member defining a contra mould surface whereby, when in a juxtaposed working relationship, the first and second members form a mould region; characterised in that in at least one of members (11) for the mould surface (12) defined by the member (11) there is provided:
a channel (13) with a first cross section including a region (P) opening into the interior of the mould region; and
an elastomeric member (18) located in and by the channel (13) defining in part a flexible wall (22) for the region;
a pressurisible duct (17) extending through the elastomeric member (18);
a passage (23) extending from the interior of the duct (17) to a location outside the mould member (11) whereby the pressure within the duct (17) can be varied to cause displacement of the flexible wall (22) between a first position (Figure 2) wherein the wall (22) is drawn inwardly to define and maintain a runner channel (24) in the mould surface (12) of the member (11); and a second position (Figure 1) wherein the wall (22) is released from forming the channel (13) and serves to provide a wall for the mould surface (12) of the member conforming substantially to that of the mould surface adjacent the channel (13) .

2 A mould tool as claimed in Claim 1 characterised in that the channel (13) has opening into it in a location not occupied by the elastomeric member forming an injection port whereby liquid resin can be injected into the mould.

3 A method of resin transfer moulding utilising a mould comprising a first member defining a face mould surface and a second member defining a contra mould surface whereby, when in a juxtaposed working relationship, the members serve to bound a mould region characterised by the steps of:

1 providing in the first member defining the face mould surface or the second member defining the contra mould surface or in each such surface a channel incorporating an elastomeric member (which is hollow so as to provide an internal duct) the elastomeric member extending over a path in the or each surface with a face of the elastomeric member directed towards the mould region;

2 providing for the face of the elastomeric member to be moved relative to the channel between:

a first state where the face is in a first configuration conforming to the surrounding region of the mould surface adjacent the channel; and

a second state where the face is in a second configuration retracted from the first into the channel so as to increase the volume of the mould region and thereby providing a channel through which mobile material (such as liquid resin) in the vicinity of the elastomeric member can flow.

4 A method of resin transfer moulding as claimed in Claim 3 characterised in that the step of providing for the face to move from the first state to the second state is caused by applying a vacuum to the internal duct.

5 A method of resin transfer moulding as claimed in Claim 3 or Claim 4 characterised in that the step of providing for the face to move from the second state to the first state is caused by applying an overpressure to the internal duct.

6 A moulded article characterised in that it is produced by means of a mould tool as claimed in Claim 1 or Claim 2.

7 A moulded article characterised in that it is produced by means of a method as claimed in Claims 3, 4 or 5.

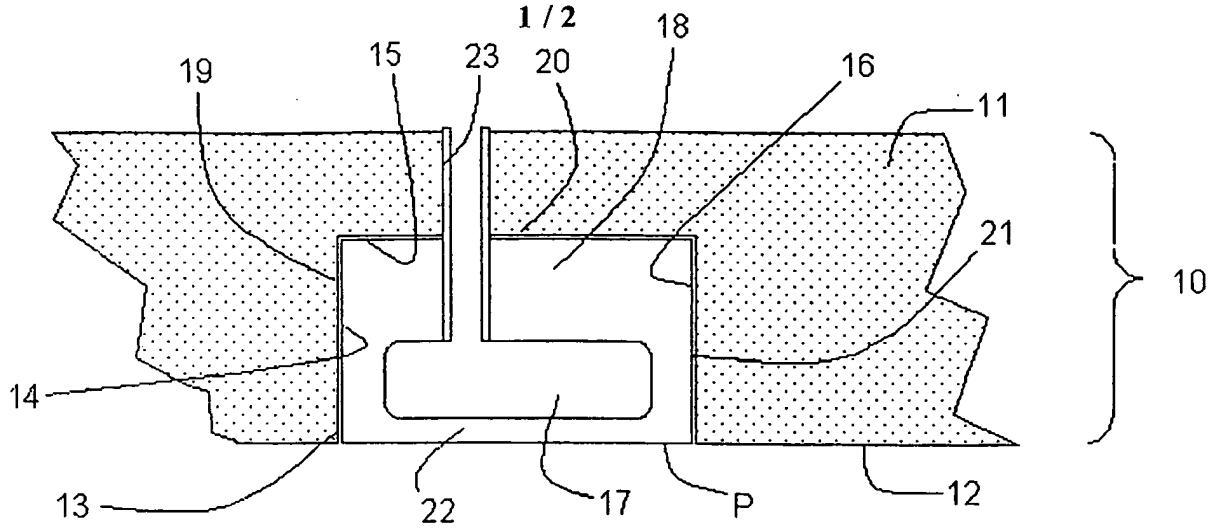


Fig 1 1/3

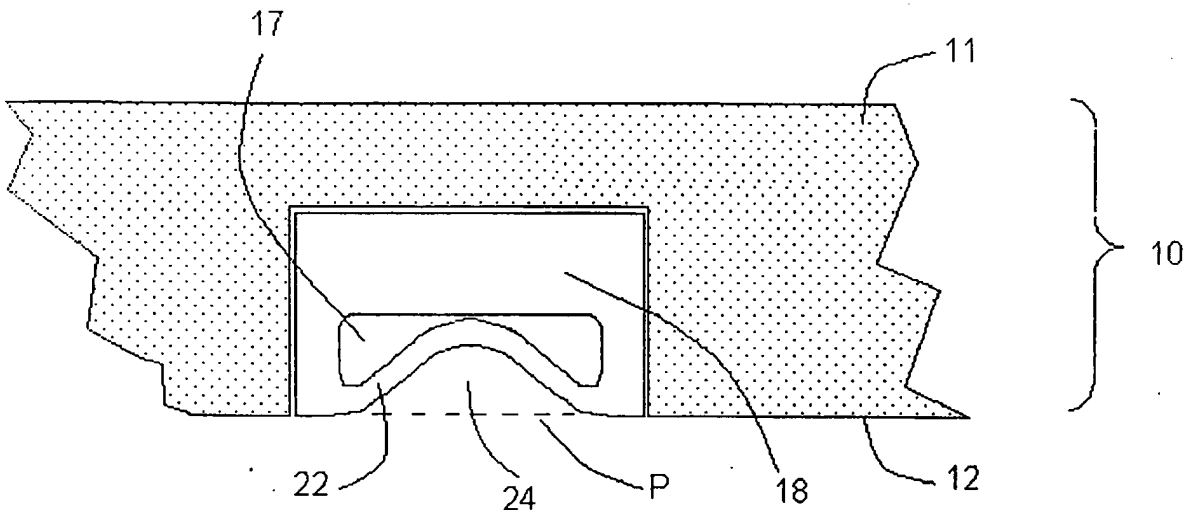


Fig 2 2/3

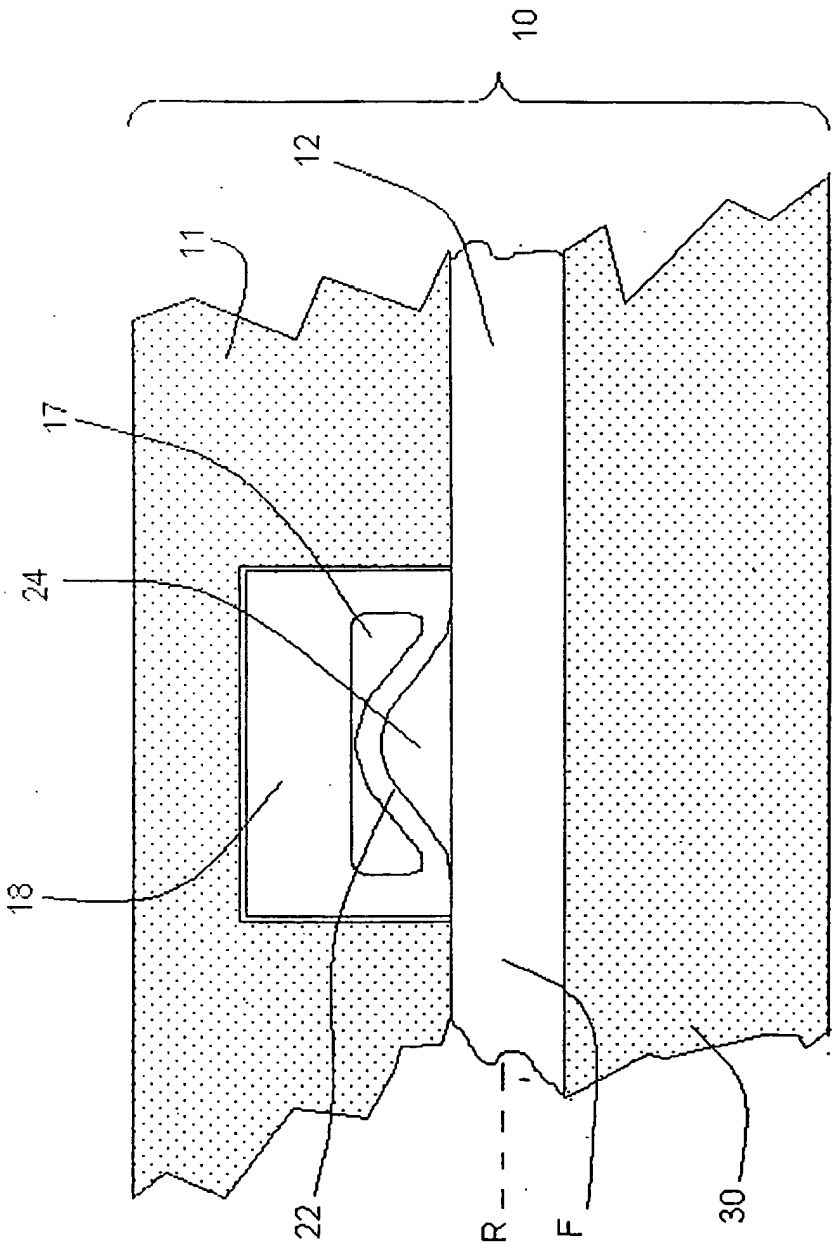


Figure 3

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/GB 00/02376

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 B29C33/40 B29C70/48 B29C33/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 322 042 A (SHELL INT RESEARCH) 28 June 1989 (1989-06-28) the whole document	1-7
Y	EP 0 445 634 A (PHOENIX AG) 11 September 1991 (1991-09-11) column 4, line 6 -column 6, line 16; figure 1	1-7
Y	EP 0 348 831 A (WEIGEL ANGELA ;WEIGEL CLAUS (DE); WEIGEL SUSANNE (DE)) 3 January 1990 (1990-01-03) column 3, line 18 -column 4, line 29; figures	1-7
X	EP 0 343 736 A (SHELL INT RESEARCH) 29 November 1989 (1989-11-29)	3,7
A	the whole document	1,2,4-6

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 October 2000	06/11/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Mathey, X

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter ·onal Application No
PCT/GB 00/02376

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0322042 A	28-06-1989	US 4873044 A	10-10-1989
		CA 1315940 A	13-04-1993
		DE 3875463 A	26-11-1992
		DE 3875463 T	04-03-1993
		ES 2035256 T	16-04-1993
		JP 1215518 A	29-08-1989
EP 0445634 A	11-09-1991	DE 4007331 A	12-09-1991
EP 0348831 A	03-01-1990	DE 3821941 A	08-02-1990
		AT 101555 T	15-03-1994
		DE 58906970 D	24-03-1994
		FI 893053 A	30-12-1989
EP 0343736 A	29-11-1989	US 4880583 A	14-11-1989
		CA 1323165 A	19-10-1993
		DE 68913348 D	07-04-1994
		DE 68913348 T	01-06-1994
		ES 2050781 T	01-06-1994
		JP 2020310 A	23-01-1990
		KR 9711569 B	12-07-1997
		US 4952135 A	28-08-1990